4

# UPPER MURRAY RIVER AND OPPOSED DRAINAGE SLOPES

By R. A. Keble

[Read 9 July 1953]


## Abstract

The Murray River has formed in what is termed the Murray Gutter where the southerly drainage slope of the Middle Eocene Tumbarumba Creek on the Munderoo Plateau became opposed to the northerly slope of the Upper Murray developed subsequently on the Murray Uplift. The Murray Gutter is believed to be the land form underlying the development and direction of the Murray. The Kosciusko Uplift extends into Victoria and is taken to have been in the first place a tectonic uplift forming a drainage divide that has, as the Great Dividing Range, moved northwards or southwards by the headward erosion of north or south flowing streams. This tectonic uplift is conceived to have been a low arching of the base-rock, the north limb of the arch extending to the Murray flows. Previous to the arching the drainage fell southwards but after it the drainage slope was reversed and the Mitta, Kiewa, Ovens and other streams became northerly or north-westerly flowing streams.


The Murray River is taken to be the stream that has its source at Forest Hill and separates Victoria from New South Wales. On some maps, for example the 8-mile map of Victoria, the Swampy Plain River is shown as the Murray; here that river is regarded as a tributary of the Murray. Here, too, the age of the basaltic lava at Tumbarumba where it has dominated the shaping of the stream system is taken to be Middle Eocene. There is in the Tumbarumba district no palaeontological evidence to establish this but its extrusion is assumed to have been contemporaneous with that of the Older Basalt of Victoria, the age of which has been deduced from contiguous marine beds. Elsewhere (Keble 1950) the author has given his reasons for assigning a Middle Eocene age to the Older Basalt and believes that palaeontological evidence indirectly associated with its occurrence may ultimately prove it to be even older. Whatever age it is found to be, the physiographical and other facts stated here can be adjusted to the emendation.

It is proposed to discuss in some detail the origin and development of Tumbarumba Creek and incidentally the Murray, the trunk stream which Tumbarumba Creek joins and which has contributed largely to the vast accumulation of Holocene and Tertiary sediments over which the Murray flows downstream from Yarrawonga. It is apparent that downstream we have a stream of Holocene or Tertiary age but upstream the Murray has cut its channel into base-rock and been doing so while the lower reaches were being covered.

## Munderoo Plateau

The valley occupied by the Tumbarumba basaltic lava was eroded on the Munderoo Plateau. Use of the term plateau arises from the view one obtains of its elevation from the Murray valley: its surface is some 1,700 feet above the Murray flood-plain. The plateau formerly extended on both sides of what is now the Murray valley before part of it south of the valley was uplifted to form the foothills leading to the Kosciusko Uplift. This uplift was partly responsible for the development and direction of the hitherto non-existent Murray.

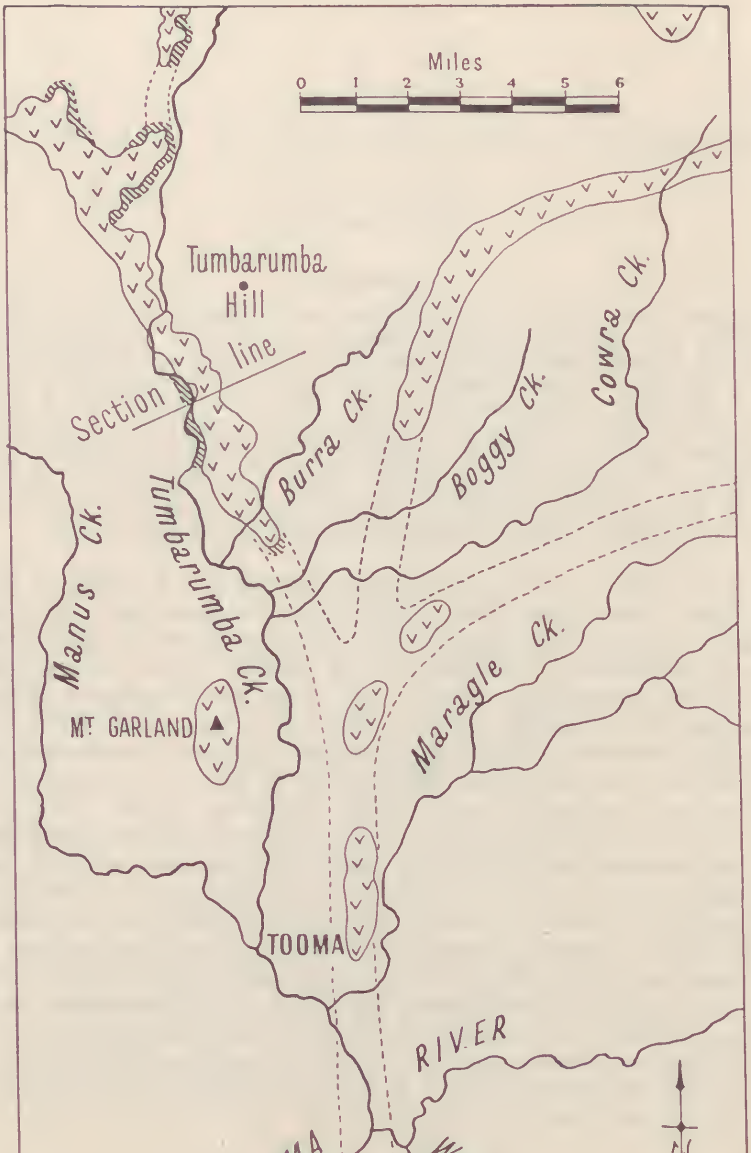


FIG. 1.—Map of Tumbarumba basaltic lava and Tumbarumba Creek, its Marginal Stream.

In reality the surface of the Munderoo Plateau is a more or less modified survival of the pre-Middle Eocene basalt land surface. Viewed from the vicinity of Munderoo, north of the Murray, where its surface is seen in an approach to its original state, it appears as a gently undulating tract of subdued topography extending south from a sinuous watershed nine miles north of Tumbarumba—a watershed that trends west and separates the Murray from the Murrumbidgee drainage systems, then south-west separating the Murray system from the westerly flowing Billabong Creek system. On the south side of the Murray its surface has been deeply dissected by streams flowing north from the Kosciusko Uplift.

Its average elevation is about 2,400 feet above sea-level but isolated eminences rise to over 3,000 feet. It slopes very gradually to the west; 60 miles to the west on the Victorian side of the Murray its average elevation is about 2,100 feet but on the New South Wales side about 1,200 feet. The S.S.E. direction of the flow of basalt in the Tumbarumba Valley as well as its marginal stream shows that the plateau also had a slope to the south. Although now dissected by streams cutting back north from the Murray, the plateau retains evidence of the old southerly drainage divides almost as far downstream as Howlong, but it was well advanced towards maturity before the extrusion of the Tumbarumba basaltic lava. We can look to the Lower Eocene, possibly the Cretaceous, for the inception of the cycle that brought this about.

No basalt occurs on the south side of the Murray.

## Development of Tumbarumba Valley, Tumbarumba Creek and Tributaries

The old valley infilled with the Middle Eocene basaltic lava trending S.S.W. from its source to Tumbarumba and from Tumbarumba S.S.E. (Fig. 1) is referred to here as the Tumbarumba Valley in contradistinction to the newer Tumbarumba Creek valley formed at the margin of the basalt (Fig. 2) as a marginal stream.

Basaltic lava poured down the Tumbarumba Valley and its tributaries to at least as far as Tooma, 15 miles S.S.E. of Tumbarumba (Fig. 1); incidentally, the basalt is known to extend from the head of the valley near Batlow for 25 miles. That the fall of the valley was to the S.S.E. is inferred from the fact that the basal flow of basalt is many feet lower in elevation at Tooma than at Tumbarumba; on the meagre data available it is estimated that the fall of the valley was about 15 feet to the mile. Remnants of the basaltic strip occur at short intervals from the head of the Tumbarumba valley to near the town of Tumbarumba; this portion of the valley has been cut wholly in granite. From Tumbarumba the strip is continuous along the S.S.E. course of the valley for about seven miles, but further S.S.E. its former continuity is evident in isolated residuals as far as Tooma. Between Burra Creek and Boggy Creek a relatively long strip of lava occupies a tributary. About four miles north of Tooma another apparently long tributary—the Maragle tributary—joined the sub-basalt stream from the north-west; the basalt that occupied the Maragle valley occurs now as isolated residuals. The most southerly residual is that in the Tumbarumba Valley east of Tooma (Fig. 1). The lava ends near the foothills of the Kosciusko Uplift.

Tumbarumba lava residual is one of the eastern Victorian types—one with a single marginal stream in the upper portion of the Tumbarumba Valley; it has, however, two marginal valleys in its southern portion near Tooma.

Tumbarumba Creek flows from near Batlow along the east margin of the infilling lava as far as Tumbarumba, where it crosses the lava to the west margin of the seven-mile strip and continues as a western marginal stream as far as Tooma; four miles S.S.E. of Tooma it joins the Tooma River, which six miles W.S.W. enters the Murray (Fig. 1) where that trunk stream turns on its general westerly course. Tumbarumba Creek retains its identity as a marginal stream until it joins the Tooma River. Less than two miles S.S.E. of Tooma, Maragle Creek cuts its channel easterly from Tumbarumba Creek south of the lava residual near Tooma thence north and north-east to become the eastern marginal stream of that residual.

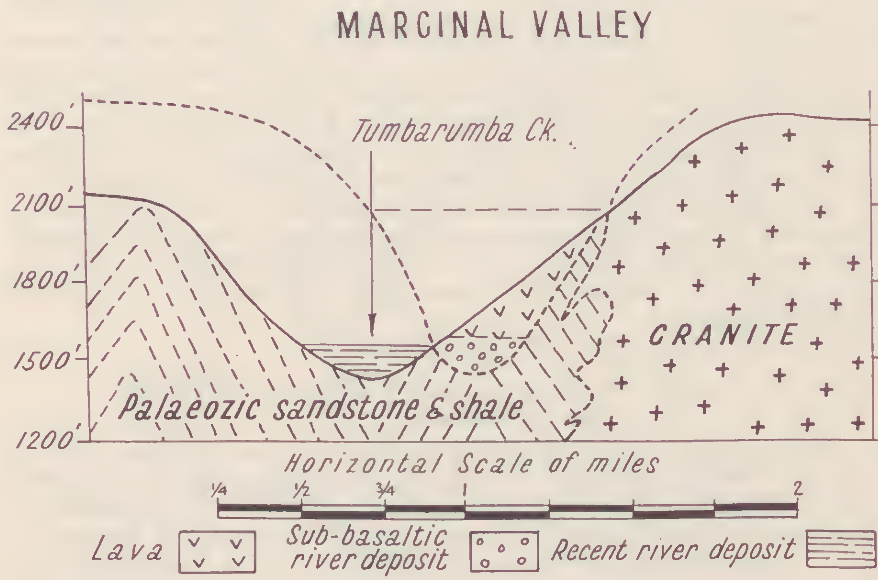


FIG. 2.—Section of Tumbarumba Lava Residual and Tumbarumba Creek marginal valley.

## MURRAY GUTTER

If, before the Kosciusko Uplift, the Tumbarumba lava extended further south than Tooma (Fig. 3) it was flanked by two marginal streams flowing south, Tumbarumba Creek on its west margin and Maragle Creek on its east margin. When these marginal valleys were raised by the uplift their drainage slopes were reversed and fell to the north; as reversed streams cut deeply into the Kosciusko Uplift we know them as the northerly flowing Upper Murray and Swampy Plain River. The spur between them may be an uncovered residual (Keble 1918). One cannot say how far the lava extended, but the significant fact is that the slope of the south flowing Tumbarumba Creek is actually opposed at the Tooma River (Fig. 3) to that of the north flowing Murray. It is a commonplace to say that where the tributaries from opposite sides of a trunk stream enter at the same place their slopes are opposed, but normal tributaries enter at different angles and their directions are not approximately coincident as are those of Tumbarumba Creek and the north flowing Murray.

Where drainage slopes are opposed, such as those at the Tooma River, a gutter (to use a mining term) is formed, referred to here as the Murray Gutter


FIG. 3.—Map showing northerly flowing Upper Murray and southerly flowing Tumbarumba Creek.

(Fig. 4). As the drainage from the Murray Gutter at the Tooma River could not escape to the north or south, and to the east it was blocked by the not far distant Marangle Range, it sought its only possible outlet over the gently westward sloping Munderoo Plateau.

This juxtaposition of drainage slopes appears to be the land form that regulated the general direction and development of the Murray downstream from where the Tooma River joins it to at least as far as Yarrawonga.

### ORIENTATION OF AXES OF LAVA RESIDUALS AND OLD DRAINAGE DIRECTION

Orientation of the axes of the Middle Eocene lava residuals both in Victoria and New South Wales affords some indication of the direction of the old sub-basalt streams; this was southward or at some departure from south. Any deviation from this general direction of the drainage was to avoid some local physical barrier or of a tributary, but sooner or later it found its way into a southward trending channel. Sub-basalt gravels tunnelled into may confirm this approach to a meridional trend, but evidence of this kind is qualified by the small extent of gravels usually penetrated; nor can the effect of tilting, such as has occurred at the Bogong High Plains lava residual, be discounted. Nevertheless such evidence may be reliable, for instance the S.S.W. and S.S.E. directions of fall of the Tumbarumba Valley and sub-basalt gravels.

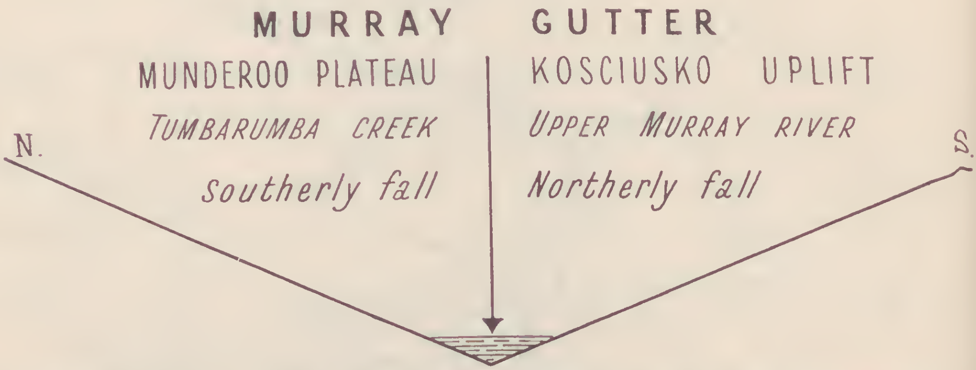


Fig. 4.—Diagrammatic Section showing Murray Gutter formed where slope of Tumbarumba Creek on Munderoo Plateau is opposed at Tooma River to that of the Upper Murray on the Kosciusko Uplift.

It may be submitted that the approximate meridional trend of the axes could indicate a northward or some departure from north trend, but the sub-basalt slope south of the Dividing Range is, apart from local deviations, southward. Moreover, the lava has resisted denudation where it covered the gravels of a major stream; it is to this fact that it owes its preservation.

Granting then a southward trend for the old Middle Eocene drainage as well as for the marginal streams that in Victoria emptied into an Eocene sea covering the lower portions of their valleys, the existence of which has been established by Baker (1943) and Raggatt and Crespin (1952), we are faced with the apparent anomaly of such streams in northern Victoria as the Kiewa and King (Ovens), marginal in their headwaters, flowing northwards. The Kiewa has perhaps developed throughout its length in a marginal valley, but the Mitta and lower reaches of the Ovens are in no way marginal. The Murray itself has cut its channel upstream from Yarrawonga diagonally across the Middle Eocene drainage slope and the pattern of the base-rock, which consists of normal and altered sediments, also granite more or less resistant to erosion; no part of it is marginal, nor seemingly has it been directed by faulting.

This conception of a reversal of the drainage slope predicates a tectonic origin for the watershed that now separates the northerly flowing from the southerly flowing streams of eastern Victoria—one that as a watershed has subsequently moved as the Dividing Range north or south with the headward erosion of the southerly or northerly flowing streams.

## Kosciusko Uplift in Victoria

The Kosciusko Uplift extends from New South Wales into Victoria, and because it occurs on both sides of a provincial boundary it would be futile to refer to it by any other name. In Fig. 5 its axis is tentatively shown as following the existing drainage divide between the northerly and southerly flowing streams. In Fig. 5 only peaks of a higher elevation than 5,500 feet are shown—from east to west, Kosciusko (7,328 ft.) and Pilot (6,020 ft.), both in New South Wales just across the provincial boundary, and in Victoria Cobboras (6,025 ft.), Gibbo (5,764 ft.), Wills (5,758 ft.), Nelson (6,170 ft.), Bogong (6,508 ft.), Fainter (6,160 ft.), Feathertop (6,306 ft.), Hotham (6,100 ft.), Howitt (5,715 ft.) and Buller (5,911 ft.). It will be noted that these high peaks group themselves about the axis. The northern slope of the Uplift reaches to the Murray; the limits of its southern fall are indefinite but are possibly as far south as Wellington (5,268 ft.) and Tamboritha (5,381 ft.). It is problematical, too, how far west the axis extends. The surface of the Bogong High Plains lava residual is, in round figures, 5,000 feet above sea-level; both the Kiewa and the Ovens head near it, but the head-waters of the Mitta, in no part a marginal stream, have breached the axis east of the Bogong High Plains and pushed back the physiographical axis. The lava residuals near the head of the King River range in elevation from 3,300 feet to 900 feet.

On the south side of the axis all streams flow from S. to S.E., except some of the headwaters of the Mitta and Limestone Creek near Forest Hill. Some of the southward flowing streams are in parts marginal. Their direction of flow is complementary to the north-westerly flowing streams on the north side of the axis; in both directions the line of flow is approximately coincident with the strike of the Palaeozoic rocks.

On the New South Wales side of the Murray west of the Munderoo Plateau the trend of the stream system is fundamentally different from that in Victoria; it is westerly and dominated by the Murrumbidgee. Nevertheless, as far west almost as Howlong there is, particularly in the westward extension of the Munderoo Plateau, modified evidence of an old system of drainage with a southward trend.

## Tectonics of Uplift

Dismissing faulting as the cause of the Kosciusko Uplift in Victoria and accepting a southward trend for the Middle Eocene drainage, it is again emphasized that a tectonic uplift is a *sine qua non* in understanding a reversal of the drainage slope.

Murray (1887) shows in a section through the Kiewa Valley the surface of the Bogong High Plains basaltic lava at elevations from about 4,000 to 6,000 feet above sea-level and fluviatile deposits beneath the lava sloping southwards from 5,000 feet to a little below 4,000 feet. The fall of the fluviatile deposits southward is about 27 feet to the mile, and while there is no doubt that they were deposited in a southerly flowing stream, we cannot exclude the effect of tilting, keeping in mind that the Bogong High Plains are near the axis of the postulated uplift. These elevations given by Murray imply an improbable land surface at about 4,000 feet above existing sea-level or 2,000 feet above the Munderoo Plateau. He shows the south flowing stream as far north as Mt. Fainter (Fig. 5) now in the northerly drainage slope of the Kiewa; the Kiewa has obviously pushed its watershed southward. It is pertinent to this discussion how far north of Fainter the south flowing stream extended. The lava on Fainter implies a land surface at about 6,000 feet but not necessarily the floor of the sub-basalt valley.

About 50 miles west of the Bogong High Plains, at Mt. Samaria, there are remnants of another formerly extensive lava flow at a maximum elevation of 3,300 feet and a minimum of 900 feet. The strip at the lower elevation has doubtless been down-faulted; it is in close proximity to a strip some 600 feet higher. Little is known about the Samaria sub-basalt gravels, but the lava at the higher level implies a land surface about 3,000 feet above existing sea-level or 1,000 feet above the surface of the Munderoo Plateau.

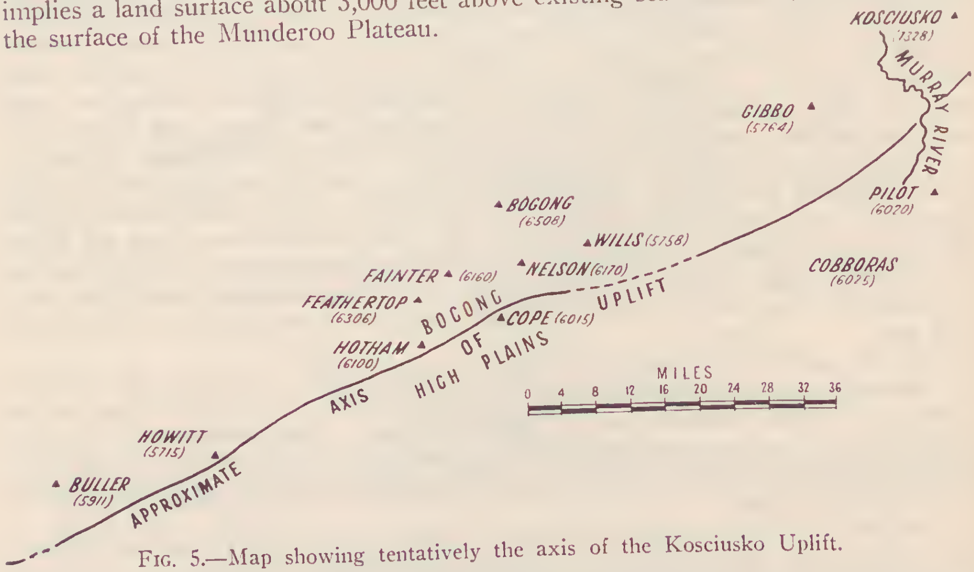


FIG. 5.—Map showing tentatively the axis of the Kosciusko Uplift.

Thus, the southward trend of the Middle Eocene drainage referred to in preliminary remarks and the S.S.W. and S.S.E. trend in the Tumbarumba Valley is corroborated by Murray in his section of the Bogong High Plains residual.

The tectonic uplift is conceived to have been caused by a low arching of the base-rock at about right angles to the general N.W. or S.E. strike. That the arch was low is evident from the fact that the angle of the northerly fall of a line from the summit of Mt. Bogong, the highest peak in Victoria, to the surface of the Munderoo Plateau near the Murray is less than a degree. The position of the arch is only tentatively shown in Fig. 5; its true position can be most convincingly located by plotting inliers in the base-rock. The inliers of older Ordovician beds near Mansfield at the western end of the axis as shown in Fig. 5 may have such a bearing. Considering the enormous amount of denudation that has occurred since the uplift, the exposure of older beds in places where there is quaquaversal dip and pitch in the base-rock is a possibility. Murray (1887) gives some idea of the excessive erosion. He states that the valley of the Dargo River, a south flowing marginal stream of the Bogong High Plains residual, has been vertically eroded to a depth of 2,800 feet below the surface of the residual. This great depth may be due to the fact that the Dargo has encroached by headward erosion into the tectonic axis. Until the tectonic axis is accurately located one cannot tell to what extent the erosional axis has deviated from it by the headward erosion of northerly or southerly flowing streams.

Briefly, it appears from the foregoing facts that such northerly and north-westerly flowing streams as the Mitta, Kiewa and Ovens have cut back on the north limb of a tectonic arch, whereas before the tectonic uplift the drainage found an outlet to the south.

## Murray Gutter and Direction of the Murray

These comments on the Murray Gutter relate to its extension downstream from where the Tooma River joins the Murray (Fig. 3) to Yarrawonga. Yarrawonga is the lowest downstream locality where the Murray is still cutting its channel into base-rock and near the debouchment into the Murray of the Ovens, some of whose headwaters—King River, Boggy Creek and Fifteen Mile Creek—are marginal streams. Doubtless the Gutter extends further downstream under Holocene fluviatile deposits that filled the Gutter and spread out from it. An enormous amount of terrigenous material has been transported by the Murray and its tributaries from the highlands of Victoria and New South Wales to form the major portion of the Holocene and Tertiary cover that extends into western Victoria, New South Wales and South Australia. This transportation has taken place since the Kosciusko Uplift and the formation of the Murray Gutter, presumably since the beginning of the Oligocene; in south-western Victoria, Oligocene marine limestone is known to overlie transported sediments. Browne, Dulhunty and Maze (1944) assign a Pliocene age to the Uplift.

The Gutter was originally formed some 1,700 feet higher than the present flood-plain of the Murray at an elevation, that of the Munderoo Plateau, of 2,400 feet above existing sea-level. All tributaries except Tumbarumba Creek now entering the Murray began then to cut back to the north or south. Those from the north join at places away from those joining from the south, indicating that, apart from the north flowing headwaters of the Murray, they did not cut back in channels existing before the formation of the Gutter. All these tributaries have developed flood-plains.

The Murray was formed in the Gutter by cutting back its channel from the west, assisted perhaps in defining its channel by overflow from the opposed Tumbarumba Creek and reversed northerly flowing Upper Murray. The vertical erosion that has lowered the Murray flood-plain into its gorge was not caused by a general uplift of the Upper Murray region but by subsidence downstream, starting probably with that which brought about the marine Tertiaries. In deepening the gorge and lowering its flood-plain the river has flowed at at least six levels. It is not intended to discuss these here except to say that the highest and oldest is about 300 feet below the surface of the Munderoo Plateau and the newest or penultimate level is about 10 feet below the surface of the flood-plain.

## References

Murray, R. A. F., 1887. *Geology and Physical Geography of Victoria.* 8vo. Melbourne.

Keble, R. A., 1918. The Significance of Lava Residuals and the Development of the Western Port and Port Phillip Drainage Systems. *Proc. Roy. Soc. Vic.*, 31: 129-165.

———, 1950. The Mornington Peninsula. *Mem. Geol. Surv. Vic.*, 17.

Baker, G., 1943. Eocene Deposits south-east of Princetown, Victoria. *Proc. Roy. Soc. Vic.*, 55: 237-255.

Browne, W. R., Dulhunty, J. A., and Maze, W. H., 1944. Notes on the Geology, Physiography, and Glaciology of the Kosciusko Area and the country north of it. *Proc. Linn. Soc. N.S.W.*, 70: 238-252.

Raggatt, R. G., and Crespin, Irene, 1952. Geology of Tertiary Rocks between Torquay and Eastern View, Victoria. *Aust. Jour. Sci.*, 14: 143-147.